STATE OF NEW YORK
DEPARTMENT OF PUBLIC WORKS

CONSTRUCTION of CONCRETE PAVEMENT JOINTS

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CONSTRUCTION OF CONCRETE PAVEMENT JOINTS

Background

Construction of joints in portland cement concrete pavement is a vital step in highway construction both from the standpoint of pavement smoothness and durability. If there is one thing which influences the public's opinion of a highway, more than any other, it is unquestionably the riding quality. Smooth pavement slabs do not always assure a good ride because roughness can be caused by uneven joints. Examination of many pavements has also shown that much of the physical deterioration of the concrete starts at the joints. Obviously, this deterioration rapidly decreases the useful life of a highway and destroys its riding quality.

Purpose

Because of the many approved methods of joint construction available to the contractor this manual has been prepared to aid the field engineer by describing and discussing each method.

Load Transfer Device - The initial step in the construction of a transverse joint is to position the load transfer device. This assembly must be placed perpendicular to the center line of the highway to permit it to function properly. If the assembly is skewed or bent, binding of the load transfer device will occur and movement of the slabs will be restrained. If the restraint is great enough the slab will crack in the vicinity of the joint.

It is important that this device be anchored securely to the subgrade. If this is not accomplished, the assembly will frequently be bent or moved by the mass of concrete being spread. The stresses tending to move or bend the load transfer device increase as the strike off and screeds approach the joint. If the center plate is bowed, serious problems will arise when the joint groove is constructed. Although unsightly, the groove will have to be constructed over the bent center plate to prevent the formation of a double crack. Unfortunately, it is not always possible to construct a crooked joint when sawed joints or joints with a rigid insert are used. In these instances, the joint assembly should be removed and replaced. If the load transfer device becomes tipped, it must be corrected immediately before the concrete sets. However, if the problem is not detected until the concrete has set, it is necessary to remove and replace the device. Therefore, caution should be observed as the paving train approaches a transverse joint.

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When the concrete is placed around the joint a pencil vibrator should be used to eliminate air pockets and assure compaction of the concrete around the load transfer device. Voids beneath the load transfer units will result in eventual faulting of the joint.

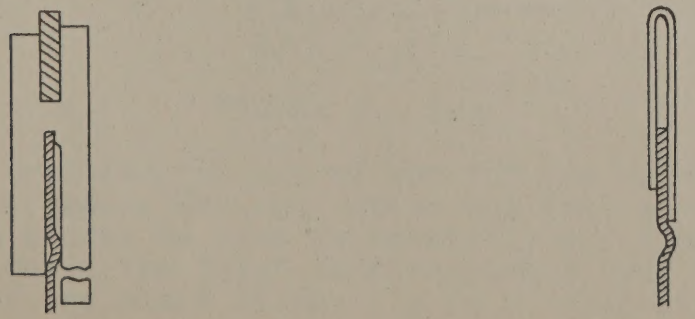
Transverse contraction joints can be separated into two groups, joints formed with inserts and sawed joints. Hand-formed contraction joints have been replaced by the above two methods.

Joint Inserts - This group includes those joints constructed by replacing the forming device with a material which can be removed after the concrete has hardened. Treated wood, two types of plastic, and a metal insert are presently approved. Other inserts require prior approval of the Deputy Chief Engineer (Highways).

The following comments apply to the category of joints formed with inserts:

1. In order to conform to the requirements of Standard Sheet 62-48X regarding installation time of a joint, all operations involved in forming a joint must be completed within 20 minutes after the placing of the concrete on the grade at the joint support assembly. This time limit was set to prevent disturbance to the concrete after it starts its initial set. Such disturbance, if permitted, could cause planes of weakness or hairline cracks which would eventually spall. This requirement has resulted in the elimination of hand formed joints.

2. At present there are two types of devices used to form the groove for the insert. One is a bar of rectangular cross section which is attached to the center plate with clips as shown in Figure 1 (a). The other is a cap which sets on the center plate, Figure 1 (b). The first is generally referred to as a forming bar and the latter a "U" or "J" cap.



(a) Forming Bar (b) "U" Cap

FIGURE 1 - Forming Devices

3. Any insert must be placed directly over the center plate. If it is even slightly offset, a parallel crack will likely occur above the center plate and the concrete between the two will eventually spall out.

4. When the insert is placed, it should be set flush with or no more than 1/8" below the pavement surface. In no case should it protrude above the pavement surface. An insert left "high" will produce a ramp or "ski jump" effect during the finishing and burlap dragging operations as shown in Figure 2. Obviously this condition is detrimental to the riding quality. If the insert is placed too low its removal may cause spalling.

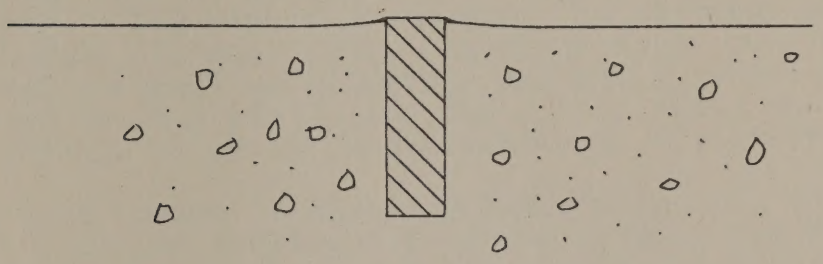


FIGURE 2

Wood Inserts - Two methods are acceptable for installing the treated wood insert. The first of these methods is by using a metal frame sometimes referred to as a "jig," (Figure No. 3).

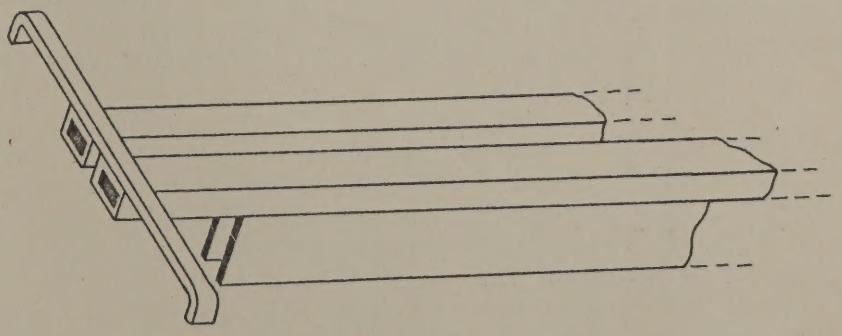


FIGURE 3 - Jig

This method requires the use of the "U" cap on the center plate of the load transfer device. After the last screed has passed the joint, a trowel is used to carefully cut along each edge of the forming cap. The "jig" is then placed over the cap in such a manner that one plate of the jig is on each side of the cap.

When the cap is lifted out between the plates, the plates serve as dams to prevent the plastic concrete from slumping back into the joint groove. The wood insert is then placed between the plates and, with the aid of a steel bar, pressed down flush with the pavement surface. The jig is withdrawn and hand darbys are used to finish the concrete. After luting and burlaping, and before placing the curing covers, the concrete mortar on top of the insert should be removed. A simple tool for removing this mortar can be made from teeth of a mowing machine blade.

On at least one contract the "jig" was too flexible and therefore didn't guarantee that the insert was placed vertically. Because it was feared that the overhanging face of the joint might break when subjected to traffic, another method was used to place the insert. A problem with concrete flowing up between the center plate and the plates of the "jig" and thus preventing the insert from being placed flush with the pavement surface has been encountered. In most instances where this occurred the slump was near the maximum permitted and small stones had become wedged between the jig plates and the center plate and widened the narrow opening to permit the concrete to infiltrate.

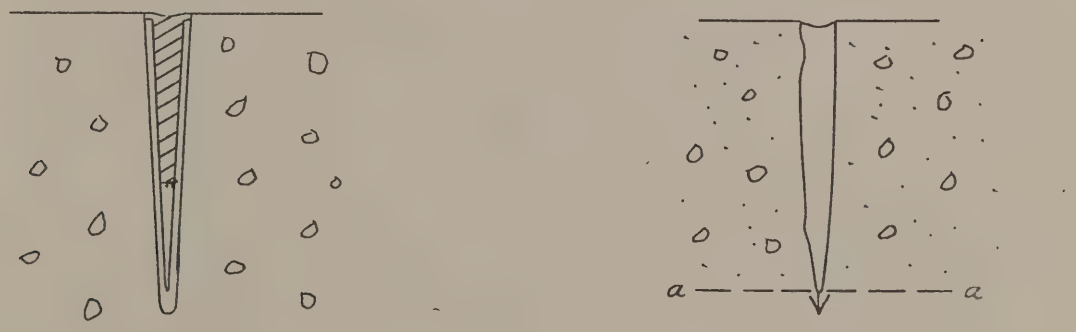
If the wood insert is placed without using the "jig," either the "U" cap or forming bar can be used as the forming device. In this method the trowel is used to peel the concrete back from the forming device. The width that the concrete is pushed back depends on the slump of the concrete. Efforts should be made to keep the concrete manipulation to a minimum. After peeling the concrete back, the forming device is removed and the wood insert is held on the center plate while concrete is replaced on each side. Care must be taken to prevent segregation of either aggregate or mortar in this operation. The finishing of the pavement is similar to that used in the first method.

After curing, and before sealing, a portion of the insert must be removed to provide room for the sealer. This is usually accomplished by mechanically sawing or grinding out the top portion of the insert. The inspector must make sure the entire width of the insert is removed so that the sealer will not bond to a thin section of insert instead of the concrete joint face. The joint should then be blown out with compressed air and sealed.

The wood insert itself must be coated to render it non-absorptive. This is important, as it is detrimental to the concrete to permit water to be removed during curing. The coating used must be compatible with the proposed joint sealer and must not remain on the joint face thereby destroying the bond between sealer and concrete.

Balsa wood and white pine are both acceptable insert materials. The balsa strips come in maximum lengths of 3 ft. and are glued together. Some problems have been encountered when the strips were not straight and in some cases the strips broke because the glue dryed out. The balsa wood can easily be removed to the desired depth by wire brushing. However, its high cost and its limited availability have caused most contractors to use white pine strips. In addition to being cheaper, strips of white pine can be obtained 12 ft. long. The white pine is removed with a milling wheel to provide room for the sealer. Yellow pine was used but proved unsatisfactory due to extreme curling. Fiber board, which has been used, absorbs water and, therefore, is no longer approved. The use of any other insert must have prior approval of the Deputy Chief Engineer (Highways).

Plastic Inserts - There are two shapes of plastic inserts used at present. The oldest is commonly referred to as the "v" or wedge type (Figure 4a) while the newer shape is a hollow tube with small fins on the base to impede floating (Figure 4b).



(a) Wedge or "v" (b) Hollow tube with fins

FIGURE 4 - Plastic Inserts

The wedge shape insert can be used with either type of forming device although it is generally used to replace the rectangular solid steel forming bar which is clipped to the center plate. A trowel is used to peel the concrete back from the forming device. As in the case of the wood insert, the amount of concrete which must be pushed back depends upon the slump of the concrete but should be kept to a minimum. The forming device is then removed and replaced with the insert. Darbys are used to float the concrete back in around the plastic wedge. Care must be taken to keep the insert over the center plate and as straight as possible. The forming bar clips aid in achieving this. This insert is extremely flexible and

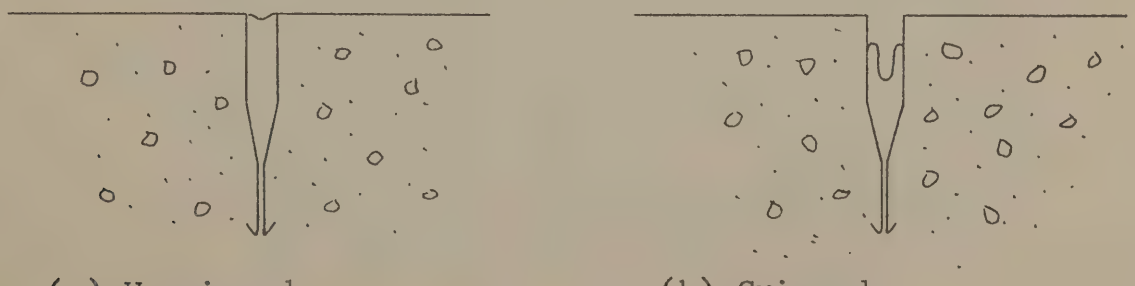
some misalignment is common but the deviations from a straight line should be kept to a minimum to prevent a parallel crack which may result from the insert being offset from the center plate. After the burlap drag has passed, the thin layer of mortar over the insert should be removed. The insert should be left in place for 48 hours. To remove the insert, the wedge is withdrawn from the "v" shaped envelope permitting the "v" to be collapsed and lifted out.

These inserts can be reused but they should be wiped clean of laitence and any concrete which might adhere to them. Coating the inserts with oils or grease to facilitate removal should not be permitted. The presence of oil or grease would prevent the joint sealer from adhering to the concrete.

The "u" cap or forming bar can also be used with the hollow tube insert. The method of installation is similar to the wedge, the only difference being that this insert is attached to the center plate with special clips before the concrete is replaced around it. If the forming bar is used, its supporting clips must be removed before the hollow tube insert is attached with the special clips. Finishing is the same as with the other types of inserts. In removing the insert the top portion (above line a-a in Figure 4b) is pulled out and discarded leaving the fins in the concrete. The insert should not be removed until the joint is to be sealed. The shape of the top of this insert tends to prevent spalling at the joint.

The hollow tube insert is more rigid than the wedge shaped insert. Therefore, the resulting joint is likely to be straighter and there is less danger that the insert will not be over the plate for the full length of the joint. Because of the fins and the special clips there should be no tendency for this insert to float.

Metal Insert - The cross section of the approved metal insert for forming transverse joints is shown in Figure No. 5 (a).



(a) Uncrimped (b) Crimped

FIGURE 5 - Metal Insert

The "U" cap or the forming bar can be used as a forming device. As with the plastic inserts a trowel is used to peel back the concrete on each side of the forming device. The slump of the concrete determines to what extent the concrete must be pushed back and again must be kept to a minimum. It is essential that the disturbance to the concrete be minimized. The forming device is removed and the metal insert placed over the center plate of the load transfer device. If clips were used to hold a forming bar they can be reused to support the metal insert. Darbys are used to smooth the concrete before luting and burlaping. The thin layer of mortar over the insert should be removed. After curing and immediately prior to sealing, the insert must be crimped to provide a reservoir for the sealer. This is done with a vibrating wheel, which when rolled along the insert crimps it to the shape shown in Figure 5 (b).

This insert is rigid and the resulting joint is straight. Due to the small metal anchors on the bottom of the insert, floating has not been a major problem. The insert will rust and therefore precautions should be taken when they are stored for some period. The rusting after placement is not serious as its main function is merely to form the joint.

Sawed Joints - The second group of joints are those which are sawed. The main difference between these and the joints previously discussed is that joints are sawed in hardened concrete whereas all others are made in plastic concrete.

No forming device is used with sawed joints. Because it is essential that the sawed joint groove be directly over the center plate of the load transfer device, care must be taken to carefully mark the center plate location. One method of marking is to attach a wire to each end guide and bend it over the concrete form. Another method is to remove the forms just prior to sawing and locate the ends of the center plate. Care should be taken if this method is used not to remove the forms before the concrete has set sufficiently. A chalk line can be snapped between the end points to mark the position of the saw cut.

During the paving operation, movement of the wire mesh reinforcement must be restricted because, if the mesh is permitted to be dragged over the center plate, two cracks will occur, one at the saw cut and the second at the end of the mesh. The repairs necessary to correct this are costly. Movement of the mesh can be limited by a proper sequence in placing the concrete and by fastening one sheet of mesh to the previous one by bending over the ends of several longitudinal wires.

When joints are sawed, the concrete is laid continuously, finished and the curing covers placed. To avoid uncovering the entire pavement when ready to saw, it is recommended that the curing covers be of such length that there will be a lap in the material at each joint location.

The determination of the time to saw the joints is important. The time varies with weather conditions and the slump of the concrete. In most instances, sawing too early is indicated by considerable raveling of the joint edges. A joint sawed at the proper time is sharp and clean with minute raveling of the joint edges. If the sawing is done too late, cracks will appear from the saw to the pavement edge as the pavement cross section is reduced by the saw cut. Another sign of late sawing is hairline cracking over load transfer devices where the joint is not yet sawed. A quick drop in temperature may also cause this type of cracking by placing the green concrete in tension. If this situation develops it would be advantageous to saw every other joint. These would then serve as relief joints, allowing the saw crew to drop back and saw the joints previously skipped. Prolonged cold weather in the fall may cause long delays before the concrete is hard enough to saw.

Abrasive or diamond blades are used to saw the transverse joints. The sawing is to be done wet, however the best results are obtained if only enough water is permitted to trickle onto the saw blade to eliminate dust and cool the saw blade. If too much water is permitted to run on the blade there is danger of scouring the mortar out of the joint face. Such scouring leaves the aggregate protruding from the joint face from 1/16" to 1/8". A perfectly sawed joint should have smooth walls. After sawing, the curing covers are immediately replaced over the joint until the curing period is over.

Sealing Joints - As required by the Public Works Specifications, all expansion, contraction and construction joints shall be sealed any time after the removal of the curing covers and before the pavement is opened to traffic, including construction traffic, and just prior to discontinuing operations when the work is suspended during the winter and just previous to acceptance. This requirement must be rigidly adhered to because unsealed joints in new concrete are easily spalled by stones being forced into the joint by construction traffic or by foreign material collecting and becoming wedged in the joint. Pavements with unsealed joints must not be opened to traffic - even contractor's traffic.

The procedure used to seal the joints depends upon the type of sealer employed. When using liquid sealers the cleanliness of a joint cannot be overemphasized. Just prior to sealing,

the joints should be wire-brushed or sand-blasted and if necessary flushed out with water and dried. This is to remove the laitence which is present on the faces of the joint. Most of the apparent adhesion failures are caused by improper cleaning. The result is that the sealer bonds itself to the laitence, dust and dirt on the face of the concrete and not the concrete itself. A pass with a powered wire brush will scrape this material loose after which it should be washed out with water and then blown out with compressed air. When dry, the joint must be sealed before more dirt can get in the joint. If a preformed sealer is used, any stones in the joint should be removed and the joint blown out clean with compressed air.

There are two types of sealers approved for use in pavements; two-component, cold poured, Thiokol-tar and preformed neoprene. The choice among approved sealers is presently the contractor's option.

When a liquid seal is used, only the top ½" is sealed. Therefore, a filler of some sort is required to support the liquid sealer until it has time to set. In the joint formed with the plastic wedge, where the joint walls slope, a paper rope is commonly used. In the rectangular shaped joint grooves a heavy rope, foam, or similar filler is generally used. The only precaution is that a bituminous impregnated filler must not be used, as the components of the sealer are not compatible with it.

When the preformed neoprene sealer is used, care must be taken that the proper width of sealer is provided. An approved lubricant-adhesive should be used to completely coat the concrete faces of the joint. It must be remembered that this type of sealer will not function unless it is under compression at all times. Yearly changes in joint openings in New York State average about 5/16" for 60' slabs. Consequently to provide for this movement, the sealer must be a minimum of 3/8" wider than the joint into which it is inserted.

During installation, care must be taken to prevent any elongation of the sealer and to place a 12' piece of sealer in a 12' joint. Stretching is undesirable because the sealer will probably shrink back to its original length when the joints open in the winter thereby leaving a portion of the joint unsealed the next spring. This preformed seal should be placed immediately after the curing paper or cover is removed and before any traffic of any kind is permitted on the pavement.

Newly laid concrete pavement must be kept free of gravel, stones and other hard objects for a period of time long enough for the concrete to attain full strength and become fully dried out.

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